ON THE MEMBRANA BASILARIS, THE MEMBRANA TECTORIA, AND THE NERVE ENDINGS IN THE HUMAN EAR.[1]

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THE materials for this investigation consisted of the ears of three human embryos and two adult males. The embryos were two and a half, three and a quarter, and four months old respectively, and since the ear capsules of these five subjects were obtained in a *practically living condition*, it was possible to use with good success both the Golgi and the methylene-blue staining methods in studying them. Both of the adults furnished ears that were normal beyond a doubt ; they came from an electrocuted murderer, on the one hand, and a robber shot *in flagrante delicto* and instantly killed, on the other hand. In the one case the ears were removed at once and preserved in an aqueous solution of corrosive sublimate, while in the other they were studied in their fresh condition. Of the embryonic ears, one was studied in the fresh condition, one was used for serial sections, while the third was used for the dissection of the membranous ear.

This exceptionally favorable adult material has given excellent results, and we may rest assured that the histology is perfectly normal and unaffected by sickness or organic disease, and, since I have used every care to preserve the living conditions in my preparations, and, by previous study of the living cochlea of mammals other than man, thoroughly prepared myself to detect alterations due to reagents, I can assure you that all of the histological characters with which we have to deal have been fixed in death as they were in life. In 1892, after several years spent in the investigation of this subject, I pub-

[1] Read at the meeting of the Association of American Anatomists, held at Ithaca, N. Y., Dec. 28–30, 1897.

lished a monograph on the vertebrate ear in which I devoted special attention to the anatomy and the histology of the mammalian cochlea, with the result that my discoveries necessitated a reconsideration of the prevailing views on the physiology of the ear. Since that time I have made several other contributions to the histology of the ear, mainly on the innervation of its sense organs. The morphological facts are admitted without question by those who have taken the pains to examine my preparations. Most physiologists and some anatomists, however, have not made use of either the facts or the physiological conclusions which necessarily flow from them, and, so far as I know, they have not troubled themselves to find out the facts. Under the circumstances, and especially because of the excellent human material which I have been fortunate enough to secure and to subject to a careful histological analysis, I am glad to bring before the Association of American Anatomists this statement of a few important facts of cochlear anatomy which are essential to a correct knowledge of the cochlea.

Membrana Basilaris.

The membrana basilaris is that part of the connective tissue wall of the cochlear tube which lies under the sense organ and forms its basement membrane. It is far from being the most delicate wall of the cochlear tube, for the membrane of Reissner is much thinner and less resistent. The importance of the basilar membrane to previous investigators was due to the dominant Helmholzt-Hensen piano-string theory of tone perception. But it is neither elastic enough nor thin and homogeneous enough to meet the requirements of this physical hypothesis. According to my latest observations, the human basilar membrane consists of four layers of fibers, three of which run radially, that is to say, from the free edge of the *lamina ossea* to the base of the stria vascularis, being continuous with the periosteum of the former structure and with the connective tissue framework of the latter part. The fourth layer, if it is permissible to call a small number of separated fibers a layer, runs at right angles to the other three ; or spirally, with reference to

the parts of the cochlea. These layers are quite distinct, and are arranged as follows : an upper and a lower layer of fine fibers inclosing between them a layer of fibers. The important imperfect layer of spiral fibers is most apparent upon the upper surface of the basilar membrane. The basilar fibers are the direct product of a part of the connective tissue cells of the embryonic basilar membrane which have been transformed into long cylindrical fibers, for the most part simple, but occasionally branched.

Auditory Cells.

The hair-bearing acoustic cells are cylindrical in shape, those of the inner row being shorter cylinders, so short, in fact, that they become ovoidal. They are surrounded and supported by the peculiarly modified non-nervous cells of the organ of Corti. The hair cells are much shorter than the supporting elements, and do not reach the basement membrane, or, as it is called, the basilar membrane, a fact of much significance in view of certain physiological hypotheses.

The hairs arise from the top of each cell as a slender bundle, the fibrils growing from all parts of the cell cap, not forming, as some assert, a crescentic or horseshoe-shaped outline upon the cell cap. Each cell bears on an average two dozen delicate, flexible filamentous hairs, which sweep inwards from the cell to end free in the endolymph above the *limbus spiralis*. The whole hair is thus supported by, or floats in the endolymph, and all the hairs from the aggregate of hair-bearing cells are so closely placed that they exert a capillary attraction upon each other, and thus, when they are loose from the tops of the cells, they remain adhering in the form of a long band or ribbon which has been called the *membrana tectoria* or damper, from its supposed rôle in auditory physiology. The long hairs are the percipient elements in the cochlea instead of the connective tissue fibers of the basement membrane of the sense organ, and the ear thus agrees with the eye, the nose, and other sense organs in the disposition of its percipient, recipient, and transmitting apparatus.

The Nerve Endings in the Ear.

The fibers of the cochlear nerve, when traced from the twisted cone of medullated fibers in the modiolus outward to the cochlear ganglion, are found to occasionally unite with or give off another fiber, which is not to be regarded as a collateral, since such fiber extends to the hair cells at the periphery in the organ of Corti. In doing so its fibrils do not pass through but around the ganglion cell, through which all the fibrils of the regular nerve fiber must pass. On gaining the ganglion cell the regular nerve fiber issues from the peripheral border of the cell as a single fiber (bipolar cell) or as from two to six distinct nerve fibers (multipolar cell), all of which then take their way towards the organ of Corti, branching as they go. These fibers may leave their radial course at any point and pass at right angle to their former course for greater or less distances (spiral nerve fibers). However, all nerve fibers leaving the cochlear ganglion sooner or later attain the organ of Corti, where they terminate in the bases of the hair cells (first method) or in a sub-acoustic nerve net from which fibers are given off to the hair cells (second method). There is thus formed a compound nerve net disposed in two layers, one above the other, immediately beneath the hair cells, which net serves to connect together hundreds of hair cells in different regions of the epithelial ridge in which the hair cells lie imbedded. Inter-epithelial or free nerve ends may occur, but I have never seen them ; all such cases are apparent, not real, so far as my observations go. The intra-cellular endings are genuine and real, and here, as elsewhere, one positive fact of observation is worth many negative observations. The facts I have stated above are all statements of my positive observations on the basilar membrane, hair cells, hairs, and nerve ends of the human ear.

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